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## (54) POLYMER DISPERSION TYPE LIQUID CRYSTAL ELEMENT AND METHOD OF MANUFACTURE

## (57)Abstract:

PROBLEM TO BE SOLVED: To prevent display unevenness and to suppress high-speed responsiveness and the relaxation of a transparent state, in a liquid crystal element having a liquid crystal polymer composite body layer wherein a dual frequency drive liquid crystal is dispersed in a polymer compound layer.

SOLUTION: Mixture of a precursor of a polymer compound, the dual frequency drive liquid crystal and a silane coupling agent having perpendicular alignment ability to the liquid crystal is injected into a cell and the precursor of the polymer compound is polymerized while no electric field is applied to the mixture to form the liquid crystal polymer composite body layer.

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(54) 【発明の名称】 高分子分散型液晶素子及びその製造方法

(57) 【要約】

【課題】 二周波駆動液晶を高分子化合物層中に分散した高分子・液晶複合体層を有する液晶素子において、表示ムラの防止、高速応答性、透明状態緩和の抑制を図る。

【解決手段】 高分子化合物の前駆体と、二周波駆動液晶と、該液晶に対する垂直配向能を有するシランカップリング剤との混合物をセル内に注入し、電場を印加せずに上記高分子化合物の前駆体を重合させて、高分子・液晶複合体層を形成する。

## 【特許請求の範囲】

【請求項1】 一対の基板と、該基板間に挟持された高分子化合物層中に正負両方の誘電率異方性の値を示す二周波駆動液晶を分散してなる高分子・液晶複合体層と、該高分子・液晶複合体層に電圧を印加するための電極とを備えた高分子分散型液晶素子であって、上記高分子・液晶複合体層が、上記液晶に対する垂直配向能を有する低分子化合物を含有することを特徴とする高分子分散型液晶素子。

【請求項2】 上記低分子化合物がシランカップリング剤である請求項1に記載の高分子分散型液晶素子。

【請求項3】 上記シランカップリング剤がオクタデシルトリエトキシシランである請求項2に記載の高分子分散型液晶素子。

【請求項4】 上記高分子・液晶複合体層中の上記低分子化合物濃度が30重量%未満である請求項1～3のいずれかに記載の高分子分散型液晶素子。

【請求項5】 上記高分子化合物が、単官能性モノマーと多官能性モノマーからなる請求項1～4のいずれかに記載の高分子分散型液晶素子。

【請求項6】 上記高分子化合物が、末端が水酸基である側鎖を有する高分子の直鎖同士を架橋してなる構造を有する請求項5に記載の高分子分散型液晶素子。

【請求項7】 上記高分子化合物における、上記末端が水酸基である側鎖の長さ、と、上記多官能性モノマー残基の長さの比が、下記の関係を満たす請求項6に記載の高分子分散型液晶素子。

0.25<(水酸基を有する側鎖の長さ/多官能性モノマー残基の長さ)<2

【請求項8】 一対の基板と、該基板間に挟持された高分子化合物層中に正負両方の誘電率異方性の値を示す二周波駆動液晶を分散してなる高分子・液晶複合体層と、該高分子・液晶複合体層に電圧を印加するための電極とを備えた高分子分散型液晶素子の製造方法であって、上記電極を備えた一対の基板間に、上記高分子化合物の前駆体と液晶と該液晶に対する垂直配向能を有する低分子化合物との混合物を充填し、上記高分子化合物の前駆体を重合させることによって、高分子・液晶複合体層を形成することを特徴とする高分子分散型液晶素子の製造方法。

【請求項9】 上記重合が光重合である請求項8に記載の高分子分散型液晶素子の製造方法。

【請求項10】 上記重合時に加熱処理を施す請求項9に記載の高分子分散型液晶素子の製造方法。

【請求項11】 上記加熱処理における温度が、液晶の等方相転移温度以上である請求項10に記載の高分子分散型液晶素子の製造方法。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】 本発明は、表示素子、光シャ

ッター素子等に用いられる液晶素子に関し、特に、メモリー性を備えた高分子分散型液晶素子と、その製造方法に関する。

## 【0002】

【従来の技術】 近年、偏光板やバックライトを必要としない高分子分散型液晶素子が、低消費電力型の表示素子として注目を集めている。このような状況の中で、メモリー性を有する二つの表示状態間（透明状態と光散乱状態）を電気的にスイッチング可能な高分子分散型液晶素子が報告されている。例えば、特開平5-61023号公報、特開平8-240819号公報及び特開平9-120058号公報には、二周波駆動液晶（誘電異方性が正負両方の値を示す液晶）を用いて、メモリー性を有する高分子分散型液晶素子を実現する方法が開示されている。

【0003】 特開平5-61023号公報に開示されている高分子分散型液晶素子は、二周波駆動液晶と高分子化合物の前駆体（以下、「高分子前駆体」と記す）との混合物を電極間に注入した後、液晶分子が基板に対して垂直方向に向くように電場を印加した状態で、上記高分子前駆体を室温近傍で重合させることにより製造する。このように作製した高分子分散型液晶素子は、電極間に印加する電圧の周波数を変化させることにより、メモリー性を有する二状態（透明状態と光散乱状態）間を遷移させることが可能である。

【0004】 また、特開平8-240819号公報や特開平9-120058号公報に開示されている高分子分散型液晶素子は、二周波駆動液晶と高分子前駆体との混合物を電極間に注入した後、上記高分子前駆体を室温近傍で重合させることにより製造する。このように作製した高分子分散型液晶素子も、電極間に印加する電圧の周波数を変化させることによりメモリー性を有する二状態（透明状態と光散乱状態）間を遷移させることが可能である。

【0005】 一方、特開平9-90329号公報には、界面活性剤またはシランカップリング剤を添加することにより、駆動特性の改善（駆動電圧の低減）を図った高分子分散型液晶素子の製造方法が開示されている。具体的には、液晶と高分子材料と界面活性剤またはシランカップリング剤からなる混合溶液を調製し、この溶液を一方の基板上に塗布し、所定の処理（例えば、加熱処理）を施してフィルムを形成し、このフィルム上にもう一方の基板を配置して素子を得ることができる。該素子を構成する高分子は、上記した従来技術とは異なり、高分子前駆体を基板上で重合して形成したものではない。

## 【0006】

【発明が解決しようとする課題】 しかしながら、上記した従来の高分子分散型液晶素子には、以下に示す問題点があった。

【0007】 （問題点1） 上記特開平5-61023号

公報に開示されている素子は、液晶と高分子前駆体との混合物を電極間に注入した後、電極間に電場を印加しながら高分子前駆体の重合を行う。この電場印加の意図は、液晶分子を電極面に対して垂直に配向させた状態で高分子前駆体を重合させるためである。しかしながら、上記混合物に対する電場印加は、前記混合物中の液晶に電界誘起型の巨視的な流動を発生させる場合がある。特に、印加電場強度を大きくして液晶分子の垂直配向度を向上させようとする、と、上記流動現象は発生しやすくなる。このような流動により、液晶分子が電極面に対して垂直に配向していない領域が形成され、この状態で高分子前駆体の重合を行うと、得られた素子に表示ムラが発生する場合があった。

【0008】（問題点2）上記特開平8-240819号公報及び特開平9-120058号公報に開示されている素子は、所望の表示状態（透明状態或いは光散乱状態）を形成するための電圧印加を解除すると、表示状態が緩和するという問題があった。特に、透明状態形成用の電圧印加を解除すると、電圧印加中に示していた光透過率よりも低下するという問題があった。

【0009】（問題点3）上記特開平8-240819号公報に開示されている素子は、応答速度が遅いという問題点があった。例えば、透明状態から光散乱状態に移させるために、光散乱状態形成用の電圧を数秒間印加する必要がある。一方、特開平5-61023号公報及び特開平9-120058号公報に開示されている素子に関しては、素子の応答速度が明記されておらず、応答速度が不明であった。

【0010】（問題点4）上記特開平9-90329号公報に開示されている素子は、メモリー性がないという問題点があった。即ち、電極間に印加した電圧を解除すると、該電圧印加時に素子が示していた状態を維持できないという問題点があった。

【0011】本発明の課題は、上記従来技術の問題点（表示状態の緩和、応答速度及び表示ムラ）を解決し、応答速度が速く、良好なメモリー性を備え、表示ムラのない液晶素子を提供することにある。

【0012】

【課題を解決するための手段】本発明の第一は、一対の基板と、該基板間に挟持された高分子化合物層中に正負両方の誘電率異方性の値を示す二周波駆動液晶を分散してなる高分子・液晶複合体層と、該高分子・液晶複合体層に電圧を印加するための電極とを備えた高分子分散型液晶素子であって、上記高分子・液晶複合体層が、上記液晶に対する垂直配向能を有する低分子化合物を含有することを特徴とする高分子分散型液晶素子である。

【0013】上記本発明の高分子分散型液晶素子は、以下の構成を好ましい態様として含むものである。上記低分子化合物がシランカップリング剤である。上記シランカップリング剤がオクタデシルトリエトキシシランであ

る。上記高分子・液晶複合体層中の上記低分子化合物濃度が30重量%未満である。上記高分子化合物が、単官能性モノマーと多官能性モノマーからなる。上記高分子化合物が、末端が水酸基である側鎖を有する高分子の直鎖同士を架橋してなる構造を有する。上記高分子化合物における、上記末端が水酸基である側鎖の長さ、と、上記多官能性モノマー残基の長さの比が、

0.25<（水酸基を有する側鎖の長さ／多官能性モノマー残基の長さ）<2

の関係を満たす。

【0014】また、本発明の第二は、一対の基板と、該基板間に挟持された高分子化合物層中に正負両方の誘電率異方性の値を示す二周波駆動液晶を分散してなる高分子・液晶複合体層と、該高分子・液晶複合体層に電圧を印加するための電極とを備えた高分子分散型液晶素子の製造方法であって、上記電極を備えた一対の基板間に、上記高分子化合物の前駆体と液晶と該液晶に対する垂直配向能を有する低分子化合物との混合物を充填し、上記高分子化合物の前駆体を重合させることによって、高分子・液晶複合体層を形成することを特徴とする高分子分散型液晶素子の製造方法である。

【0015】上記本発明の製造方法においては、上記重合が光重合であること、該重合時に加熱処理を施すこと、該加熱処理における温度が、液晶の等方相転移温度以上であること、を好ましい態様として含むものである。

【0016】

【発明の実施の形態】本発明の特徴は、高分子・液晶複合体層中に、液晶に対して垂直配向能を有する低分子化合物（以下、「垂直配向化合物」と記す）を含有せしめたことにある。本発明においては、高分子化合物の前駆体（高分子前駆体）と液晶との混合物に該垂直配向化合物を添加して、該前駆体を重合させることにより、電場を印加することなく、良好に液晶が分散した高分子・液晶複合体層を得、同時に、良好なメモリー性も発現させることができる。

【0017】本発明で用いる垂直配向化合物は、本発明で用いる二周波駆動液晶に対して垂直配向させる機能を有する低分子化合物である。即ち、該垂直配向化合物により表面処理された基板間に液晶を挟持した場合には、該液晶は垂直配向を示す。本発明では、このような性質を有する低分子化合物であれば用いることができ、その種類に制限はないが、好ましくは、シランカップリング剤が挙げられ、例えば、炭素原子数10～22のアルキル基、フッ素化されていても良いアルキル基を有するトリアルコキシシランまたはトリハロシラン等のシランカップリング剤を挙げることができる。より具体的には、デシルトリメトキシシラン、デシルトリクロロシラン、ドデシルトリエトキシシラン、テトラデシルトリクロロシラン、オクタデシルトリエトキシシラン、オクタ

デシルトリクロロシラン、エイコシルトリクロロシラン、ドコシルトリクロロシラン、トリデカフルオロオクチルトリクロロシラン、トリデカフルオロオクチルトリメトキシシラン等が挙げられる。さらには、レシチン、ステアリン酸、CTAB（ヘキサデシルトリメチルアンモニウムブロマイド）、オクタデシルアミンハイドロクロライド、一塩基性カルボン酸クロム錯体（例：ミスチリン酸クロム錯体）なども挙げることができる。

【0018】本発明にかかる垂直配向化合物の、高分子・液晶複合体層中における濃度は、液晶素子に所望の特性を発現させることができれば特に制限はないが、好ましくは30重量%未満、より好ましくは20重量%未満であり、望ましくは10重量%未満である。

【0019】本発明において用いられる二周波駆動液晶は、印加電圧の周波数に応じて正負両方の誘電異方性を示す液晶であり、例えば、チッソ社製の二周波駆動液晶混合物「DF01XX」が好ましく用いられるが、該液晶は印加電圧の周波数が5kHz以下であれば誘電異方性は正の値を、10kHz以上であれば負を示す。

【0020】本発明では、二周波駆動液晶として2種類以上の低分子液晶化合物からなる混合物も好ましく用いられ、このような低分子液晶化合物としては、2, 3-ジシアノ-4-ペンチルオキシフェニル-4-（トランス-4-エチルシクロヘキシル）ベンゾアート、2, 3-ジシアノ-4-エトキシフェニル-4-（トランス-4-ペンチルシクロヘキシル）ベンゾアート、2, 3-ジシアノ-4-エトキシフェニル-4-（トランス-4-ブチルシクロヘキシル）ベンゾアート、4-シアノフェニル-4'-ペンチル-4-ビフェニルカルボキシレート等を挙げることができる。

【0021】本発明で用いられる高分子前駆体としては、好ましくは光重合性であり、好ましくは1種以上の単官能性モノマーと1種以上の多官能性モノマーとの混合物が挙げられる。

【0022】上記単官能性モノマーとしては、例えば、2-エチルヘキシル（メタ）アクリレート、2-ヒドロキシエチル（メタ）アクリレート、2-ヒドロキシプロピル（メタ）アクリレート、ブタンジオールモノ（メタ）アクリレート、ヘキサジオール（メタ）アクリレート、フェノキシエチル（メタ）アクリレート、テトラヒドロフルフリル（メタ）アクリレート、アクリル酸4-ヒドロキシブチル等を挙げることができる。

【0023】また、多官能性モノマーは上記単官能性モノマーと結合可能な官能基を備えた材料であり、2官能性モノマーとしては、ビスフェノールAEO変性ジアクリレート、イソシアヌル酸EO変性ジアクリレート、トリプロピレングリコールジアクリレート、ペンタエリスリトールジアクリレートモノステアレート、ポリエチレングリコールジアクリレート、ポリプロピレングリコールジアクリレート、1, 4-ブタンジオールジアクリレ

ート、1, 6-ヘキサジオールジアクリレート、日本化薬社製「Kayarad R167、HX220、HX620、R684」等を挙げることができる。

【0024】さらに3官能性或いはそれ以上の多官能性モノマーとしては、トリメチロールプロパントリアクリレート、トリメチロールプロパントリエトキシアクリレート、変性グリセリントリアクリレート、ペンタエリスリトールトリアクリレート、変性トリメチロールプロパントリアクリレート、ペンタエリスリトールテトラアクリレート、ジトリメチロールプロパントテトラアクリレート、ジペンタエリスリトールペンタアクリレート、ジペンタエリスリトールヘキサアクリレート、トリス（2-ヒドロキシエチル）イソシアヌレート（メタ）アクリレート、ジペンタエリスリトールカプロラクタム変性アクリレート（日本化薬社製「DPCA-20、30、60、120」）等を挙げることができる。

【0025】本発明では、上記高分子前駆体を重合して得られる高分子化合物が側鎖末端に水酸基を有していることが好ましく、このような高分子化合物としては、例えば、前記2-ヒドロキシエチルメタアクリレートと1, 6-ヘキサジオールジアクリレートとの混合物を重合させることにより得ることができる。

【0026】さらに本発明にかかる高分子化合物は、上記水酸基を有する側鎖の長さと同官能性モノマー残基の長さの比が下記の関係にあることが好ましい。

$0.25 < (\text{水酸基を有する側鎖の長さ} / \text{多官能性モノマー残基の長さ}) < 2$

上記した単官能性モノマーと多官能性モノマーからなる高分子前駆体中における単官能性モノマーの濃度は40重量%以上、好ましくは50重量%～90重量%である。

【0027】図1に、本発明の液晶素子の基本構成の断面模式図を示す。図中、1a、1bは透明基板、2a、2bは電極、3は高分子・液晶複合体層、4はスペーサーである。

【0028】本発明の液晶素子の製造方法においては、透明基板1a、1bにそれぞれ電極2a、2bを形成し、必要に応じてスペーサー4を用いて基板間ギャップを均一に保持し、両基板を貼り合わせて空セルを形成し、該空セル内に高分子前駆体と液晶と垂直配向化合物の混合物を注入した後、該高分子前駆体を重合し、高分子・液晶複合体層3を形成する。

【0029】上記混合物中における液晶の濃度は好ましくは30重量%～90重量%、より好ましくは40重量%～80重量%である。本発明においては、該混合物中に重合開始剤を添加しても良く、例えば、高分子前駆体を紫外線照射により光重合させる場合には、光重合開始剤を用いることができる。光重合開始剤としては、例えば、1-ヒドロキシシクロヘキシルフェニルケトン（チバ・ガイギー社製「イルガキュア184」）、ベンジル

ジメチルケタール（同社製「イルガキュア651」）等を挙げることができる。また、光開始剤の添加濃度は、高分子前駆体と液晶と垂直配向化合物の混合物総重量に対して0.1～5重量%であることが好ましい。

【0030】本発明にかかる高分子前駆体は、好ましくは光重合により重合して、高分子・液晶複合体層を形成するが、この時、必要に応じて加熱処理を施しても良く、その場合には、加熱温度は用いる液晶の等方相転移温度より高く設定することが好ましい。

【0031】本発明の液晶素子は、印加する電界の周波数を適宜選択することによって、メモリー性を有する透明状態或いは光散乱状態に液晶を移行させることによって表示を行うことができるが、液晶の良好な配向性を得る上で、高分子・液晶複合体層3に接する基板界面、即ち図1においては電極2a、2bの高分子・液晶複合体層3に接する表面に、配向処理が施されていることが好ましい。該配向処理としては、用いる液晶の性質によって適宜選択され、水平配向処理や垂直配向処理が用いられる。垂直配向処理としては、セチルトリメチルアンモニウムブロマイド、オクタデシルエトキシシラン等を用い、気相吸着、浸漬、スピコート等の方法により基板表面に配向処理を施すことができる。水平配向処理としては、ポリイミド、ポリビニルアルコール等からなる薄膜を電極上に設け、該薄膜をラビングすることにより形成することができる。また、必要がなければ配向処理を施さなくてもかまわない。

【0032】また、本発明の液晶素子の他の部材としては、特に限定されず、従来の液晶素子の構成部材を用いることができる。例えば、基板1a、1bとしては、通常ガラス等透明基板が用いられ、電極2a、2bはITO等透明導電材で形成される。

【0033】本発明の液晶素子においては、高分子・液晶複合体層に第1の周波数の電圧を印加した場合に、該複合体層は第1の状態を発現し、第2の周波数の電圧を印加した場合には、第2の状態を発現する。本発明では、上記第1の状態が透明状態であり、第2の状態が光散乱状態（不透明状態）である。よって、第1の周波数は、液晶が正の誘電異方性を示す領域にあり、第2の周波数は液晶が負の誘電異方性を示す領域にある。

【0034】本発明の液晶素子は、上記第1の状態、第2の状態がそれぞれ第1の周波数の電圧印加、第2の周波数の電圧印加を解除した後もほぼ維持される、メモリー性を備えている。即ち、前記した従来の技術で問題点として挙げられた、表示状態の緩和が抑制される。その理由としては、電界印加解除後の液晶分子の配向緩和が、高分子・液晶複合体層に含まれる垂直配向化合物の存在によって抑制されるためであると推測される。

【0035】また、本発明の液晶素子は、高分子前駆体の重合時に電場を印加していないため、該重合時に液晶の巨視的な流動が起きておらず、よって、素子全面にお

いて均一な高分子・液晶複合体層が形成され、上記流動に起因する表示ムラの発生が防止される。

【0036】以上説明したように、本発明の液晶素子は、垂直配向化合物（例えばシランカップリング剤）を含有していることを特徴とするが、前述した従来技術（特開平9-90239号）におけるシランカップリング剤を含有する液晶素子とは、構成上明らかに異なるものである。具体的には、液晶と高分子化合物との界面におけるシランカップリング剤の分布状態が異なる。

【0037】上記従来技術の素子における液晶と高分子化合物との界面に存在するシランカップリング剤は、液晶滴と高分子化合物との界面を被覆するように分布している。そのため、該界面において、液晶が高分子化合物に接触している割合が極めて小さくなるので、液晶と高分子化合物との相互作用（アンカリング）が極端に弱くなっている。その結果、素子の駆動電圧が低減している。

【0038】アンカリングが弱まれば、表示メモリー性、特に透明状態の表示メモリー性が損なわれる。本発明の液晶素子においては、表示メモリー性が優れていることから、液晶と高分子化合物との界面に存在する垂直配向化合物は、比較的疎に分布し、垂直配向化合物がアンカリングを弱めるようには分布していないものと考えられる。

【0039】アンカリングが弱まることで、透明状態のメモリー性が損なわれる理由を説明する。先ず、素子への電圧印加により、該素子を透明状態とする。ここで、電圧印加を解除しなければ該透明状態は維持される。この時、液晶は配向状態にあり、電圧印加を解除すると、液晶の垂直配向状態は崩壊しようとする。アンカリングが弱いと、この液晶の垂直配向状態の崩壊を抑制できない。即ち、透明状態をメモリーできない。

【0040】表示状態をメモリーさせるアンカリングの実体の詳細は不明であるが、少なくとも本発明の液晶素子において使用している高分子化合物に含まれる水酸基が重要な働きをしているものと推測される。従って、垂直配向化合物は、この水酸基のアンカリング機能を損なわないように分布していると言える。

【0041】尚、前記従来の技術の液晶素子は、シランカップリング剤の有無に関わらず、表示にメモリー性が無く、また、用いられている高分子化合物は、液晶と高分子前駆体の混合物において該前駆体を重合したものではない。よって、本発明の液晶素子で用いられている高分子化合物とは構成上異なるものである。

【0042】本発明の液晶素子は、上記した2状態（透明状態、光散乱状態）を利用して、光シャッター素子とすることが可能である。また、そのまま透過型の液晶素子として用いる一方、一方の基板の裏面に光反射板或いは着色板を設ければ、反射型の液晶素子として利用することもできる。

## 【0043】

【実施例】（実施例1）アクリル酸4-ヒドロキシブチルを50重量部と日本化薬社製「Kayarad R167」を40重量部と1, 6-ヘキサジオールジアクリレートを10重量部からなる高分子前駆体30重量部と、二周波駆動液晶（チソ社製「DFO1XX」、等方相転移温度=106.5℃）70重量部と、シランカップリング剤（オクタデシルトリエトキシシラン）3重量部と、光重合開始剤（チバ・ガイギー社製「イルガキュア184」）1重量部とを混合した。該混合物は液状であり、以下、混合溶液1と呼ぶ。

【0044】上記混合溶液1を、表面温度が110℃に維持されているホットプレート状においたセルの中空部に注入した。該セルは、2枚のガラス基板上にそれぞれITO電極を形成し、その表面にセチルトリメチルアンモニウムブロマイドによる垂直配向処理を施し、7μmのスペーサーを介して対向配置させてなる。

【0045】上記ホットプレート温度を110℃に維持した状態で、上記セルに強度1mW/cm<sup>2</sup>の紫外線を10分間照射した。これにより、高分子前駆体が重合し、セル内に高分子・液晶複合体層が形成された。紫外線照射を停止した後、ホットプレートの加熱も停止した。その後、液晶セルをホットプレート上に設置した状態で、セル温度が27℃になるまで冷却した。得られた液晶素子は、光散乱による白濁を呈していた。空セルの状態での光透過率を100%として、この光散乱状態における液晶素子の光透過率は19%であった。

【0046】得られた本例の液晶素子の温度を27℃に保ち、液晶素子の電極間に±80V、1kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は透明状態（光透過率=95%）を示し、該電圧印加後も透明状態（光透過率=89%）を維持していた。即ち、透明状態の緩和は透過率で6%程度であった。

【0047】次に、本例の液晶素子に±80V、100kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は光散乱状態（光透過率=10%）を示し、電圧印加後も光散乱状態（光透過率=20%）を維持していた。即ち、光散乱状態の緩和は透過率で10%程度であった。

【0048】さらに、本例の液晶素子に、上記±80V、1kHzの矩形波と±80V、100kHzの矩形波とを100msec交互に液晶素子に印加することにより、メモリー性を有する透明状態（印加電圧解除後の光透過率=89%）と光散乱状態（印加電圧解除後の光透過率=20%）を交互に形成することができた。この様子を図2に示す。

【0049】（比較例1）アクリル酸4-ヒドロキシブチルを50重量部と日本化薬社製「Kayarad R167」を40重量部と1, 6-ヘキサジオールジアクリレートを1重量部からなる高分子前駆体30重量部

と、二周波駆動液晶（チソ社製「DFO1XX」）70重量部と、光重合開始剤（チバ・ガイギー社製「イルガキュア184」）1重量部とを混合して混合溶液2を調製した。

【0050】上記混合溶液2を混合溶液1の代わりに用いる以外は実施例1と同様にして液晶素子を作製した。冷却完了直後の液晶素子は光散乱による白濁を呈し、空セルの状態での光透過率を100%として、この光散乱状態における液晶素子の光透過率は19%であった。

【0051】得られた本例の液晶素子の温度を27℃に保ち、液晶素子の電極間に±80V、1kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は透明状態（光透過率=95%）を示し、該電圧印加後も透明状態（光透過率=85%）を維持していた。

【0052】次に、本例の液晶素子に±80V、100kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は光散乱状態（光透過率=10%）を示し、電圧印加後も光散乱状態（光透過率=19%）を維持していた。

【0053】さらに、本例の液晶素子に、上記±80V、1kHzの矩形波と±80V、100kHzの矩形波とを100msec交互に液晶素子に印加することにより、メモリー性を有する透明状態（印加電圧解除後の光透過率=85%）と光散乱状態（印加電圧解除後の光透過率=19%）を交互に形成することができた。即ち、本例の液晶素子における透明状態及び光散乱状態の緩和はそれぞれ透過率変化で10%と9%であり、透明状態の緩和が実施例1の透明状態の緩和に比べて大きかった。

【0054】（実施例2）2枚のガラス基板のそれぞれにITO電極を設け、ポリイミド膜を設けてラビング処理を施した後、5μmのスペーサーを介して対向配置して構成したセルを用いた以外は、実施例1と同様にして液晶素子を作製した。

【0055】冷却完了直後の液晶素子は、光散乱による白濁を呈し、空セルの状態での光透過率を100%として、この光散乱状態における液晶素子の光透過率は20%であった。

【0056】得られた本例の液晶素子の温度を27℃に保ち、液晶素子の電極間に±80V、1kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は透明状態（光透過率=96%）を示し、該電圧印加後も透明状態（光透過率=90%）を維持していた。即ち、透明状態の緩和は透過率変化で6%程度であった。

【0057】次に、本例の液晶素子に±80V、100kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は光散乱状態（光透過率=14%）を示し、電圧印加後も光散乱状態（光透過率=21%）を維持していた。即ち、光散乱状態の緩和は透過率変化で7%程度であった。



【0058】さらに、本例の液晶素子に、上記±80V、1kHzの矩形波と±80V、100kHzの矩形波とを100msec交互に液晶素子に印加することにより、メモリー性を有する透明状態（印加電圧解除後の光透過率＝90％）と光散乱状態（印加電圧解除後の光透過率＝21％）を交互に形成することができた。

【0059】（比較例2）混合溶液1の代わりに比較例1で用いた混合溶液2を用いた以外は実施例2と同様にして液晶素子を作製した。冷却完了直後の液晶素子は光散乱による白濁を呈し、空セルの状態での光透過率を100％として、この光散乱状態における液晶素子の光透過率は20％であった。

【0060】得られた本例の液晶素子の温度を27℃に保ち、液晶素子の電極間に±80V、1kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は透明状態（光透過率＝96％）を示し、該電圧印加後も透明状態（光透過率＝86％）を維持していた。

【0061】次に、本例の液晶素子に±80V、100kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は光散乱状態（光透過率＝14％）を示し、電圧印加後も光散乱状態（光透過率＝20％）を維持していた。

【0062】さらに、本例の液晶素子に、上記±80V、1kHzの矩形波と±80V、100kHzの矩形波とを100msec交互に液晶素子に印加することにより、メモリー性を有する透明状態（印加電圧解除後の光透過率＝86％）と光散乱状態（印加電圧解除後の光透過率＝20％）を交互に形成することができた。即ち、本例の液晶素子における透明状態及び光散乱状態の緩和はそれぞれ透過率変化で10％と6％であり、透明状態の緩和が実施例2の透明状態の緩和に比べて大きかった。

【0063】（実施例3）2枚のガラス基板のそれぞれにITO電極を設け、配向処理を施さずに5μmのスペーサーを介して対向配置して構成したセルを用いた以外は、実施例1と同様にして液晶素子を作製した。

【0064】冷却完了直後の液晶素子は、光散乱による白濁を呈し、空セルの状態での光透過率を100％として、この光散乱状態における液晶素子の光透過率は19％であった。

【0065】得られた本例の液晶素子の温度を27℃に保ち、液晶素子の電極間に±80V、1kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は透明状態（光透過率＝96％）を示し、該電圧印加後も透明状態（光透過率＝91％）を維持していた。即ち、透明状態の緩和は透過率変化で5％程度であった。

【0066】次に、本例の液晶素子に±80V、100kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は光散乱状態（光透過率＝14％）を示し、電圧印加後も光散乱状態（光透過率＝20％）を維

持していた。即ち、光散乱状態の緩和は透過率変化で6％程度であった。

【0067】さらに、本例の液晶素子に、上記±80V、1kHzの矩形波と±80V、100kHzの矩形波とを100msec交互に液晶素子に印加することにより、メモリー性を有する透明状態（印加電圧解除後の光透過率＝91％）と光散乱状態（印加電圧解除後の光透過率＝20％）を交互に形成することができた。

【0068】（比較例3）混合溶液1の代わりに比較例1で用いた混合溶液2を用いた以外は実施例3と同様にして液晶素子を作製した。冷却完了直後の液晶素子は光散乱による白濁を呈し、空セルの状態での光透過率を100％として、この光散乱状態における液晶素子の光透過率は19％であった。

【0069】得られた本例の液晶素子の温度を27℃に保ち、液晶素子の電極間に±80V、1kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は透明状態（光透過率＝96％）を示し、該電圧印加後も透明状態（光透過率＝85％）を維持していた。

【0070】次に、本例の液晶素子に±80V、100kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は光散乱状態（光透過率＝14％）を示し、電圧印加後も光散乱状態（光透過率＝19％）を維持していた。

【0071】さらに、本例の液晶素子に、上記±80V、1kHzの矩形波と±80V、100kHzの矩形波とを100msec交互に液晶素子に印加することにより、メモリー性を有する透明状態（印加電圧解除後の光透過率＝85％）と光散乱状態（印加電圧解除後の光透過率＝19％）を交互に形成することができた。即ち、本例の液晶素子における透明状態及び光散乱状態の緩和はそれぞれ透過率変化で11％と5％であり、透明状態の緩和が実施例2の透明状態の緩和に比べて大きかった。

【0072】（実施例4）実施例1の液晶素子の一方の表面（裏面）に黒色の光吸収層を設けた。

【0073】本液晶素子に±80V、1kHzの矩形波電圧を印加し、表面より観察したところ、光吸収層の色である黒色が観察された。また、電圧印加を解除した後も黒色を呈していた。

【0074】次に、本例の液晶素子に±80V、100kHzの矩形波電圧を印加したところ、液晶素子は光散乱状態、即ち白色を呈していた。また、電圧印加を解除した後も白色を維持していた。

【0075】さらに、上記±80V、1kHzの矩形波と±80V、100kHzの矩形波とを100msec交互に液晶素子に印加することにより、メモリー性を有する黒色と白色とを交互に形成することができた。

【0076】（実施例5）アクリル酸4-ヒドロキシブチルを50重量部と1,6-ヘキサジオールジアクリ



レートと5重量部からなる高分子前駆体50重量部と、二周波駆動液晶（チッソ社製「DF01XX」）50重量部と、シランカップリング剤（オクタデシルトリエトキシシラン）3重量部と、光重合開始剤（チバ・ガイギー社製「イルガキュア184」）1重量部とを混合し、混合溶液3を調製した。

【0077】混合溶液1の代わりに上記混合溶液3を用いる以外は実施例1と同様にして液晶素子を作製した。冷却完了直後の液晶素子は、光散乱による白濁を呈し、空セルの状態での光透過率を100%として、この光散乱状態における液晶素子の光透過率は19%であった。

【0078】得られた本例の液晶素子の温度を27℃に保ち、液晶素子の電極間に±80V、1kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は透明状態（光透過率=95%）を示し、該電圧印加後も透明状態（光透過率=88%）を維持していた。即ち、透明状態の緩和は透過率変化で7%程度であった。

【0079】次に、本例の液晶素子に±80V、100kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は光散乱状態（光透過率=10%）を示し、電圧印加後も光散乱状態（光透過率=22%）を維持していた。

【0080】さらに、本例の液晶素子に、上記±80V、1kHzの矩形波と±80V、100kHzの矩形波とを100msec交互に液晶素子に印加することにより、メモリー性を有する透明状態（印加電圧解除後の光透過率=88%）と光散乱状態（印加電圧解除後の光透過率=22%）を交互に形成することができた。

【0081】（比較例4）アクリル酸4-ヒドロキシブチルを50重量部と1,6-ヘキサジオールジアクリレートと5重量部からなる高分子前駆体50重量部と、二周波駆動液晶（チッソ社製「DF01XX」）50重量部と、光重合開始剤（チバ・ガイギー社製「イルガキュア184」）1重量部とを混合し、混合溶液4を調製した。

【0082】混合溶液3の代わりに上記混合溶液4を用いる以外は実施例5と同様にして液晶素子を作製した。冷却完了直後の液晶素子は、光散乱による白濁を呈し、空セルの状態での光透過率を100%として、この光散

乱状態における液晶素子の光透過率は19%であった。

【0083】得られた本例の液晶素子の温度を27℃に保ち、液晶素子の電極間に±80V、1kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は透明状態（光透過率=95%）を示し、該電圧印加後も透明状態（光透過率=80%）を維持していた。

【0084】次に、本例の液晶素子に±80V、100kHzの矩形波電圧を100msec印加した。電圧印加中、液晶素子は光散乱状態（光透過率=10%）を示し、電圧印加後も光散乱状態（光透過率=21%）を維持していた。

【0085】さらに、本例の液晶素子に、上記±80V、1kHzの矩形波と±80V、100kHzの矩形波とを100msec交互に液晶素子に印加することにより、メモリー性を有する透明状態（印加電圧解除後の光透過率=80%）と光散乱状態（印加電圧解除後の光透過率=21%）を交互に形成することができた。即ち、本例の液晶素子における透明状態及び光散乱状態の緩和はそれぞれ透過率変化で15%と11%であり、透明状態の緩和が実施例5の透明状態の緩和に比べて大きかった。

【0086】

【発明の効果】以上説明したように、本発明によれば、表示ムラが無く、高速応答性でメモリー性を有し、特に、透明状態の緩和が抑制された液晶素子を煩雑な製造工程を経ることなく提供することができ、表示素子や光シャッター素子として好ましく適用することができる。

【図面の簡単な説明】

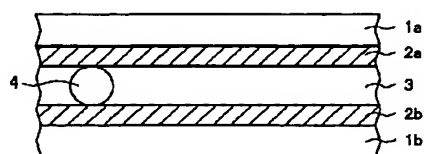
【図1】本発明の液晶素子の基本構成を示す断面模式図である。

【図2】本発明の実施例において、液晶素子に周波数の異なる矩形波を交互に印加した場合の透過率変化を示す図である。

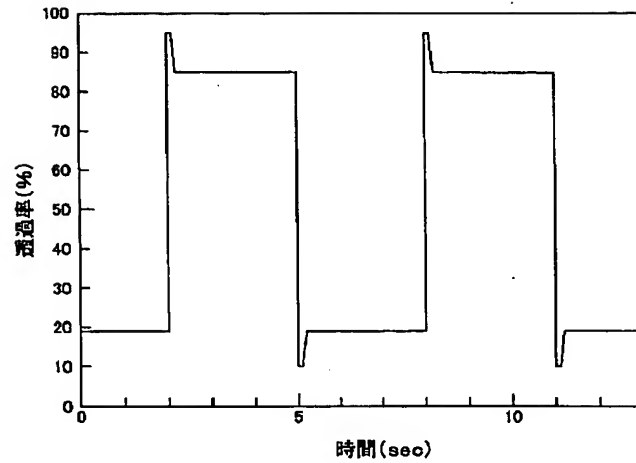
【符号の説明】

- 1a、1b 基板
- 2a、2b 電極
- 3 高分子・液晶複合体層
- 4 スペース

【図1】



【図2】



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フロントページの続き

Fターム(参考) 2H089 HA04 JA04 JA05 KA08 QA12  
QA14 QA16  
4J002 AA051 BG041 BG051 BG071  
DA117 EF057 EH126 EN117  
EN137 EX027 EX037 FD206  
GP03  
4J011 AA05 AC04 PA47 PB40 PC02  
QA03 QA12 QA13 QA17 QA23  
QA24 QA25 SA54 SA58 SA61  
UA01 VA01 WA01

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CLAIMS

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[Claim(s)]

[Claim 1] The macromolecule and liquid crystal complex layer which comes to distribute the dual tone multifrequency actuation liquid crystal which shows the value of the dielectric constant anisotropy of both positive/negative in the high-molecular-compound layer pinched between the substrate of a couple, and this substrate, The polymer dispersed liquid crystal component which is a polymer dispersed liquid crystal component equipped with the electrode for impressing an electrical potential difference to this macromolecule and liquid crystal complex layer, and is characterized by the above-mentioned macromolecule and liquid crystal complex layer containing the low molecular weight compound which has the vertical orientation ability to the above-mentioned liquid crystal.

[Claim 2] The polymer dispersed liquid crystal component according to claim 1 whose above-mentioned low molecular weight compound is a silane coupling agent.

[Claim 3] The polymer dispersed liquid crystal component according to claim 2 whose above-mentioned silane coupling agent is octadecyl triethoxysilane.

[Claim 4] The polymer dispersed liquid crystal component according to claim 1 to 3 whose above-mentioned low-molecular-weight-compound concentration in the above-mentioned macromolecule and liquid crystal complex layer is less than 30 % of the weight.

[Claim 5] The polymer dispersed liquid crystal component according to claim 1 to 4 which the above-mentioned high molecular compound becomes from a monofunctional nature monomer and a polyfunctional monomer.

[Claim 6] The polymer dispersed liquid crystal component according to claim 5 which has the structure where the above-mentioned high molecular compound comes to construct a bridge in the straight chains of a macromolecule which have the side chain whose end is a hydroxyl group.

[Claim 7] The polymer dispersed liquid crystal component according to claim 6 with which the ratio of the die length of the side chain whose above-mentioned end in the above-mentioned high molecular compound is a hydroxyl group, and the die length of the above-mentioned polyfunctional monomer residue fills the following relation.

$0.25 < (\text{die length of die-length} / \text{polyfunctional monomer residue of side chain which has hydroxyl group})$

$< 2$  -- [Claim 8] The macromolecule and liquid crystal complex layer which comes to distribute the dual tone multifrequency actuation liquid crystal which shows the value of the dielectric constant anisotropy of both positive/negative in the high-molecular-compound layer pinched between the substrate of a couple, and this substrate, It is the manufacture approach of the polymer dispersed liquid crystal component equipped with the electrode for impressing an electrical potential difference to this macromolecule and liquid crystal complex layer. By being filled up with mixture with the low molecular weight compound which has the vertical orientation ability to the precursor, the liquid crystal, and this liquid crystal of the above-mentioned high molecular compound between the substrates of the couple equipped with the above-mentioned electrode, and carrying out the polymerization of the precursor of the above-mentioned high molecular compound The manufacture approach of the polymer dispersed liquid crystal component characterized by forming a macromolecule and a liquid crystal complex layer.

[Claim 9] The manufacture approach of a polymer dispersed liquid crystal component according to claim 8 that the above-mentioned polymerization is photopolymerization.

[Claim 10] The manufacture approach of a polymer dispersed liquid crystal component according to claim 9 of heat-treating at the time of the above-mentioned polymerization.

[Claim 11] The manufacture approach of a polymer dispersed liquid crystal component according to claim 10 that the temperature in the above-mentioned heat-treatment is more than the isotropic phase transition

temperature of liquid crystal.

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[Translation done.]

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**DETAILED DESCRIPTION**

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the polymer dispersed liquid crystal component especially equipped with memory nature, and its manufacture approach about the liquid crystal device used for a display device, an optical shutter component, etc.

[0002]

[Description of the Prior Art] In recent years, the polymer dispersed liquid crystal component which needs neither a polarizing plate nor a back light attracts attention as a display device of a low-power mold. In such a situation, between two display conditions of having memory nature (a transparence condition and light-scattering condition) is electrically reported to the switchable polymer dispersed liquid crystal component. For example, the method of realizing the polymer dispersed liquid crystal component which has memory nature is indicated by JP,5-61023,A, JP,8-240819,A, and JP,9-120058,A using dual tone multifrequency actuation liquid crystal (liquid crystal which a dielectric anisotropy shows the value of both positive/negative).

[0003] After pouring the mixture of dual tone multifrequency actuation liquid crystal and the precursor (it is hereafter described as a "macromolecule precursor") of a high molecular compound into inter-electrode, the polymer dispersed liquid crystal component currently indicated by JP,5-61023,A is in the condition which impressed electric field so that a liquid crystal molecule may be perpendicularly suitable to a substrate, and is manufactured by carrying out the polymerization of the above-mentioned macromolecule precursor near the room temperature. Thus, as for the produced polymer dispersed liquid crystal component, it is possible to make between the 2 conditions (a transparence condition and light-scattering condition) of having memory nature change by changing the frequency of the electrical potential difference impressed to inter-electrode.

[0004] Moreover, the polymer dispersed liquid crystal component currently indicated by JP,8-240819,A and JP,9-120058,A is manufactured by carrying out the polymerization of the above-mentioned macromolecule precursor near the room temperature, after pouring the mixture of dual tone multifrequency actuation liquid crystal and a macromolecule precursor into inter-electrode. Thus, also as for the produced polymer dispersed liquid crystal component, it is possible to make between the 2 conditions (a transparence condition and light-scattering condition) of having memory nature change by changing the frequency of the electrical potential difference impressed to inter-electrode.

[0005] On the other hand, the manufacture approach of a polymer dispersed liquid crystal component of having aimed at the improvement (reduction of driver voltage) of an actuation property is indicated by JP,9-90329,A by adding a surfactant or a silane coupling agent. The mixed solution which consists of liquid crystal, polymeric materials, a surfactant, or a silane coupling agent is specifically prepared, this solution is applied on one substrate, predetermined processing (for example, heat-treatment) is performed, a film is formed, on this film, another substrate can be arranged and a component can be obtained. The macromolecule which constitutes this component is not what unlike the above-mentioned conventional technique carried out the polymerization of the macromolecule precursor and formed it on the substrate.

[0006]

[Problem(s) to be Solved by the Invention] However, there was a trouble shown below in the above-mentioned conventional polymer dispersed liquid crystal component.

[0007] (Trouble 1) The component currently indicated by above-mentioned JP,5-61023,A performs the polymerization of a macromolecule precursor, impressing electric field to inter-electrode, after pouring the mixture of liquid crystal and a macromolecule precursor into inter-electrode. The intention of this electric-

field impression is for carrying out the polymerization of the macromolecule precursor, where orientation of the liquid crystal molecule is vertically carried out to an electrode surface. However, the electric-field impression to the above-mentioned mixture may make the liquid crystal in said mixture generate macroscopic floating of an electric-field induction mold. If impression electric field strength tends to be enlarged and it is going to raise the vertical amount of preferred orientation of a liquid crystal molecule especially, it will become easy to generate the above-mentioned floating phenomenon. When the field the liquid crystal molecule has not carried out [ the field ] orientation vertically to the electrode surface was formed of such floating and the polymerization of a macromolecule precursor was performed in this condition by it, the case where display nonuniformity occurred was in the obtained component.

[0008] (Trouble 2) The component currently indicated by above-mentioned JP,8-240819,A and JP,9-120058,A had the problem that a display condition eased, when the electrical-potential-difference impression for forming a desired display condition (a transparence condition or light-scattering condition) was canceled. When the electrical-potential-difference impression for transparence condition formation was canceled especially, there was a problem of falling rather than the light transmittance shown during electrical-potential-difference impression.

[0009] (Trouble 3) The component currently indicated by above-mentioned JP,8-240819,A had the trouble that a speed of response was slow. For example, in order to make a light-scattering condition change from a transparence condition, it is necessary to impress the electrical potential difference for light-scattering condition formation for several seconds. On the other hand about the component currently indicated by JP,5-61023,A and JP,9-120058,A, the speed of response of a component was not specified, but the speed of response was unknown.

[0010] (Trouble 4) The component currently indicated by above-mentioned JP,9-90329,A had the trouble that there was no memory nature. That is, when the electrical potential difference impressed to inter-electrode was canceled, there was a trouble that the condition that the component showed was unmaintainable, at the time of this electrical-potential-difference impression.

[0011] The technical problem of this invention solves the trouble (relaxation, the speed of response, and display nonuniformity of a display condition) of the above-mentioned conventional technique, its speed of response is quick, it is equipped with good memory nature, and is to offer a liquid crystal device without display nonuniformity.

[0012]

[Means for Solving the Problem] The macromolecule and liquid crystal complex layer which comes to distribute the dual tone multifrequency actuation liquid crystal which shows the value of the dielectric constant anisotropy of both positive/negative in the high-molecular-compound layer pinched between the substrate of a couple, and this substrate the first of this invention, It is the polymer dispersed liquid crystal component equipped with the electrode for impressing an electrical potential difference to this macromolecule and liquid crystal complex layer, and the above-mentioned macromolecule and liquid crystal complex layer are the polymer dispersed liquid crystal components characterized by containing the low molecular weight compound which has the vertical orientation ability to the above-mentioned liquid crystal.

[0013] The polymer dispersed liquid crystal component of above-mentioned this invention includes the following configurations as a desirable mode. The above-mentioned low molecular weight compound is a silane coupling agent. The above-mentioned silane coupling agent is octadecyl triethoxysilane. The above-mentioned low-molecular-weight-compound concentration in the above-mentioned macromolecule and liquid crystal complex layer is less than 30 % of the weight. The above-mentioned high molecular compound consists of a monofunctional nature monomer and a polyfunctional monomer. It has the structure where the above-mentioned high molecular compound comes to construct a bridge in the straight chains of a macromolecule which have the side chain whose end is a hydroxyl group. The ratio of the die length of the side chain whose above-mentioned end in the above-mentioned high molecular compound is a hydroxyl group, and the die length of the above-mentioned polyfunctional monomer residue fills the relation of  $0.25 < (\text{die length of die-length} / \text{polyfunctional monomer residue of side chain which has hydroxyl group}) < 2$ .

[0014] Moreover, the macromolecule and liquid crystal complex layer which comes to distribute the dual tone multifrequency actuation liquid crystal which shows the value of the dielectric constant anisotropy of both positive/negative in the high-molecular-compound layer pinched between the substrate of the second couple of this invention, and this substrate, It is the manufacture approach of the polymer dispersed liquid crystal component equipped with the electrode for impressing an electrical potential difference to this macromolecule and liquid crystal complex layer. By being filled up with mixture with the low molecular weight compound which has the vertical orientation ability to the precursor, the liquid crystal, and this liquid

crystal of the above-mentioned high molecular compound between the substrates of the couple equipped with the above-mentioned electrode, and carrying out the polymerization of the precursor of the above-mentioned high molecular compound. It is the manufacture approach of the polymer dispersed liquid crystal component characterized by forming a macromolecule and a liquid crystal complex layer.

[0015] In the manufacture approach of above-mentioned this invention, the temperature in that the above-mentioned polymerization is photopolymerization, heat-treating at the time of this polymerization, and this heat-treatment includes as a desirable mode that it is more than the isotropic phase transition temperature of liquid crystal.

[0016]

[Embodiment of the Invention] The description of this invention is in having made the low molecular weight compound (it being hereafter described as a "vertical orientation compound") which has vertical orientation ability to liquid crystal in a macromolecule and a liquid crystal complex layer contain. Without impressing electric field by adding this vertical orientation compound into the mixture of the precursor (macromolecule precursor) of a high molecular compound, and liquid crystal, and carrying out the polymerization of this precursor, the macromolecule and liquid crystal complex layer which liquid crystal distributed good can be obtained, and good memory nature can also be made to discover simultaneously in this invention.

[0017] The vertical orientation compound which can be used by this invention is a low molecular weight compound which has the function which carries out vertical orientation to the dual tone multifrequency actuation liquid crystal used by this invention. That is, when liquid crystal is pinched between the substrates by which surface treatment was carried out with this vertical orientation compound, this liquid crystal shows vertical orientation. In this invention, although it can use if it is the low molecular weight compound which has such a property, and there is no limit in the class, silane coupling agents, such as a thoria RUKOKI silane which a silane coupling agent is mentioned, for example, has preferably the alkyl group of the carbon atomic numbers 10-22 and the alkyl group which may be fluorinated, or a TORIHARO silane, can be mentioned. More specifically, decyltrimetoxysilane, decyltrichlorosilane, dodecyltriethoxysilane, tetradecyl trichlorosilane, octadecyl triethoxysilane, octadecyl trichlorosilane, EIKO sill trichlorosilane, DOKOSHIRU trichlorosilane, trideca fluoro octyl trichlorosilane, trideca fluoro octyl trimethoxysilane, etc. are mentioned. Furthermore, lecithin, stearin acid, CTAB (hexadecyl trimethylammonium star's picture), octadecyl amine hydro chloride, a little salt machine nature carboxylic-acid chromium complex (example: misty phosphoric-acid chromium complex), etc. can be mentioned.

[0018] Although there will be especially no limit if the concentration in a macromolecule and a liquid crystal complex layer of the vertical orientation compound concerning this invention can make a liquid crystal device discover a desired property, preferably, less than 30% of the weight, it is less than 20 % of the weight more preferably, and is less than 10 % of the weight desirably.

[0019] Although the dual tone multifrequency actuation liquid crystal used in this invention is liquid crystal in which the dielectric anisotropy of both positive/negative is shown according to the frequency of applied voltage, for example, the dual tone multifrequency actuation liquid crystal mixture "DF01XX" by Chisso Corp. is used preferably, this liquid crystal shows negative, if the frequency of applied voltage is 5kHz or less, and a dielectric anisotropy is 10kHz or more about a forward value.

[0020] In this invention, the mixture which consists of two or more kinds of low-molecular-liquid-crystal compounds as dual tone multifrequency actuation liquid crystal is also used preferably. As such a low-molecular-liquid-crystal compound 2, 3-dicyano-4-pentyloxy phenyl-4-(transformer-4-ethyl cyclohexyl) benzoate, 2, 3-dicyano-4-ethoxy phenyl-4-(transformer-4-pentyl cyclohexyl) benzoate, 2, 3-dicyano-4-ethoxy phenyl-4-(transformer-4-butyl cyclohexyl) benzoate, 4-cyanophenyl-4'-pentyl-4-biphenyl carboxylate, etc. can be mentioned.

[0021] As a macromolecule precursor used by this invention, it is photopolymerization nature preferably, and the mixture of one or more sorts of monofunctional nature monomers and one or more sorts of polyfunctional monomers is mentioned preferably.

[0022] As the above-mentioned monofunctional nature monomer, 2-ethylhexyl (meta) acrylate, 2-hydroxyethyl (meta) acrylate, 2-hydroxypropyl (meta) acrylate, butanediol monochrome (meta) acrylate, hexandiol (meta) acrylate, phenoxy ethyl (meta) acrylate, tetrahydrofurfuryl (meta) acrylate, acrylic-acid 4-hydroxy butyl, etc. can be mentioned, for example.

[0023] A polyfunctional monomer is the ingredient equipped with the functional group in which the above-mentioned monofunctional nature monomer and association are possible. Moreover, as a 2 functionality monomer Bisphenol A EO denaturation diacrylate, isocyanuric acid EO denaturation diacrylate, Tripropylene glycol diacrylate, pentaerythritol diacrylate monostearate, Polyethylene-glycol diacrylate,



polypropylene-glycol diacrylate, 1,4-butanediol diacrylate, 1,6-hexanediol diacrylate, the Nippon Kayaku Co., Ltd. make (Kayarad R167, and "HX220, HX620, R684"), etc. can be mentioned.

[0024] As further 3 functionality or a polyfunctional monomer beyond it Trimethylolpropane triacrylate, trimethylol propane TORIETOKISHI acrylate, Denaturation glyceryl triacrylate, a pentaerythritol thoria chestnut rate, Denaturation trimethylolpropane triacrylate, pentaerythritol tetraacrylate, Ditrimeethylolpropanetetraacrylate, dipentaerythritol pentaacrylate, Dipentaerythritol hexaacrylate, tris (2-hydroxyethyl) isocyanurate (meta) acrylate, dipentaerythritol caprolactam denaturation acrylate (Nippon Kayaku Co., Ltd. make (DPCA-20, and "30, 60,120")), etc. can be mentioned.

[0025] In this invention, it is desirable that the high molecular compound obtained by carrying out the polymerization of the above-mentioned macromolecule precursor has the hydroxyl group at the side-chain end, and it can obtain as such a high molecular compound by carrying out the polymerization of the mixture of said 2-hydroxyethyl methacrylate and 1,6-hexanediol diacrylate, for example.

[0026] As for the high molecular compound furthermore applied to this invention, it is desirable that the ratio of the die length of a side chain and the die length of polyfunctional monomer residue which has the above-mentioned hydroxyl group has the following relation.

The concentration of the monofunctional nature monomer in the macromolecule precursor which consists of a monofunctional nature monomer described above  $0.25 < (\text{die length of die-length} / \text{polyfunctional monomer residue of side chain which has hydroxyl group}) < 2$ , and a polyfunctional monomer is 50 % of the weight - 90 % of the weight preferably 40% of the weight or more.

[0027] The cross section of the basic configuration of the liquid crystal device of this invention is shown in drawing 1 . For 1a and 1b, a transporence substrate, 2a, and 2b of an electrode and 3 are [ a macromolecule and a liquid crystal complex layer and 4 ] spacers among drawing.

[0028] In the manufacture approach of the liquid crystal device of this invention to the transporence substrates 1a and 1b, respectively Electrode 2a, After holding the gap between substrates to homogeneity using a spacer 4 if needed, sticking both substrates, forming [ forming 2b, ] an empty cel and pouring in the mixture of a macromolecule precursor, liquid crystal, and a vertical orientation compound into this empty cel, the polymerization of this macromolecule precursor is carried out, and a macromolecule and the liquid crystal complex layer 3 are formed.

[0029] The concentration of the liquid crystal in the above-mentioned mixture is 40 % of the weight - 80 % of the weight more preferably 30 % of the weight to 90% of the weight. In this invention, when a polymerization initiator may be added in this mixture, for example, it carries out photopolymerization of the macromolecule precursor by UV irradiation, a photopolymerization initiator can be used. As a photopolymerization initiator, 1-hydroxy cyclohexyl phenyl ketone (the "IRUGA cure 184" by Ciba-Geigy), benzyl dimethyl ketal (the "IRUGA cure 651" by the company), etc. can be mentioned, for example. Moreover, as for the addition concentration of a photoinitiator, it is desirable that it is 0.1 - 5 % of the weight to the mixture AUW of a macromolecule precursor, liquid crystal, and a vertical orientation compound.

[0030] Although the polymerization of the macromolecule precursor concerning this invention is preferably carried out according to photopolymerization and a macromolecule and a liquid crystal complex layer are formed, at this time, you may heat-treat if needed and, as for whenever [ stoving temperature ], it is desirable to set up more highly than the isotropic phase transition temperature of the liquid crystal to be used in that case.

[0031] Although the liquid crystal device of this invention can be displayed by making liquid crystal shift to the transporence condition or the light-scattering condition of having memory nature by choosing the frequency of the electric field to impress suitably It is desirable that orientation processing is performed to the substrate interface which touches a macromolecule and the liquid crystal complex layer 3, i.e., the front face which touches electrode 2a, and the macromolecule and liquid crystal complex layer 3 of 2b in drawing 1 , when acquiring the good stacking tendency of liquid crystal. As this orientation processing, it is suitably chosen by the property of the liquid crystal to be used, and level orientation processing and vertical orientation processing are used with it. Orientation processing can be performed to a substrate front face by the approach of gas phase adsorption, immersion, a spin coat, etc., using a cetyl trimethylammonium star's picture, an octadecyl ethoxy silane, etc. as vertical orientation processing. As level orientation processing, the thin film which consists of polyimide, polyvinyl alcohol, etc. can be prepared on an electrode, and it can form by carrying out rubbing of this thin film. Moreover, orientation processing may not be performed without the need.

[0032] Moreover, especially as other members of the liquid crystal device of this invention, it is not limited

but the configuration member of the conventional liquid crystal device can be used. For example, as substrates 1a and 1b, transparence substrates, such as glass, are usually used and electrode 2a and 2b are formed by transparence electric conduction material, such as ITO.

[0033] In the liquid crystal device of this invention, when the electrical potential difference of the 1st frequency is impressed to a macromolecule and a liquid crystal complex layer, this complex layer discovers the 1st condition, and when the electrical potential difference of the 2nd frequency is impressed, the 2nd condition is discovered. In this invention, the 1st condition of the above is in a transparence condition, and the 2nd condition is in a light-scattering condition (opaque condition). Therefore, the 1st frequency has liquid crystal in the field which shows a forward dielectric anisotropy, and the 2nd frequency has liquid crystal in the field which shows a negative dielectric anisotropy.

[0034] The liquid crystal device of this invention is equipped with the memory nature maintained mostly even after the 1st condition of the above and the 2nd condition cancel electrical-potential-difference impression of the 1st frequency, and electrical-potential-difference impression of the 2nd frequency, respectively. That is, relaxation of the display condition mentioned as a trouble by the above mentioned Prior art is controlled. As the reason, orientation relaxation of the liquid crystal molecule after electric-field impression discharge is conjectured to be because for it to be controlled by existence of the vertical orientation compound contained in a macromolecule and a liquid crystal complex layer.

[0035] Moreover, since the liquid crystal device of this invention is not impressing electric field at the time of the polymerization of a macromolecule precursor, macroscopic floating of liquid crystal does not occur at the time of this polymerization, but therefore, on the whole component surface, uniform macromolecule and liquid crystal complex layer are formed, and generating of the display nonuniformity resulting from the above-mentioned floating is prevented.

[0036] As explained above, as for the liquid crystal device containing the silane coupling agent in the conventional technique (JP,9-90239,A) mentioned above, the liquid crystal devices of this invention differ constitutionally clearly [ although characterized by containing the vertical orientation compound (for example, silane coupling agent) ]. Specifically, the distribution conditions of the silane coupling agent in the interface of liquid crystal and a high molecular compound differ.

[0037] The silane coupling agent which exists in the interface of the liquid crystal and the high molecular compound in the component of the above-mentioned conventional technique is distributed so that the interface of a liquid crystal drop and a high molecular compound may be covered. Therefore, in this interface, since the rate that liquid crystal touches the high molecular compound becomes very small, the interaction (anchoring) of liquid crystal and a high molecular compound is extremely weak. Consequently, the driver voltage of a component is decreasing.

[0038] If anchoring becomes weaker, display-memory nature, especially the display-memory nature of a transparence condition will be spoiled. In the liquid crystal device of this invention, since display-memory nature is excellent, the vertical orientation compound which exists in the interface of liquid crystal and a high molecular compound is comparatively distributed over a non-dense, and it is thought [ whose a vertical orientation compound weakens anchoring ] that it is not distributed like.

[0039] By anchoring becoming weaker, why the memory nature of a transparence condition is spoiled is explained. First, this component is made into a transparence condition by electrical-potential-difference impression to a component. Here, if electrical-potential-difference impression is not canceled, this transparence condition is maintained. If liquid crystal is in an orientation condition and electrical-potential-difference impression is canceled at this time, the vertical orientation condition of liquid crystal tends to collapse. If anchoring is weak, breaking of the vertical orientation condition of this liquid crystal cannot be controlled. That is, the memory of the transparence condition cannot be carried out.

[0040] Although the detail of the stereo of anchoring to which memory of the display condition is carried out is unknown, it is guessed that the hydroxyl group contained in the high molecular compound currently used in the liquid crystal device of this invention at least is what is carrying out important work. Therefore, it can be said that the vertical orientation compound is distributed so that the anchoring function of this hydroxyl group may not be spoiled.

[0041] In addition, the liquid crystal device of said Prior art is not concerned with the existence of a silane coupling agent, there is no memory nature in a display, and the high molecular compound used is not what carried out the polymerization of this precursor in the mixture of liquid crystal and a macromolecule precursor. Therefore, it differs from the high molecular compound used by the liquid crystal device of this invention constitutionally.

[0042] The liquid crystal device of this invention can be considered as an optical shutter component using

the two above-mentioned conditions (a transparence condition, light-scattering condition). Moreover, if a light reflex plate or a coloring plate is formed in the rear face of one substrate while using as a liquid crystal device of a transparency mold as it is, it can also use as a liquid crystal device of a reflective mold.

[0043]

[Example] The macromolecule precursor 30 weight section which consists [ butyl / acrylic-acid 4-hydroxy ] 40 weight sections and 1,6-hexanediol diacrylate of the 10 weight sections in 50 weight sections and "Kayarad R167" by Nippon Kayaku Co., Ltd., (Example 1) The dual tone multifrequency actuation liquid crystal ("DF01XX", isotropic phase transition temperature = 106.5 degrees C) 70 weight section, the silane coupling agent (octadecyl triethoxysilane) 3 weight section, and the photopolymerization initiator (the "IRUGA cure 184" by Ciba-Geigy) 1 weight section were mixed. [ by Chisso Corp. ] This mixture is liquefied and is hereafter called a mixed solution 1.

[0044] It poured into the centrum of a cel which set the above-mentioned mixed solution 1 in the shape of [ skin temperature is maintained by 110 degrees C ] a hot plate. This cel forms an ITO electrode on two glass substrates, respectively, performs vertical orientation processing by the cetyl trimethylammonium star's picture to the front face, and it is made to come to carry out opposite arrangement through a 7-micrometer spacer.

[0045] Where the above-mentioned hot plate temperature is maintained at 110 degrees C, the ultraviolet rays of on-the-strength 1 mW/cm<sup>2</sup> were irradiated for 10 minutes at the above-mentioned cel. Thereby, the macromolecule precursor carried out the polymerization and the macromolecule and the liquid crystal complex layer were formed in the cel. After suspending UV irradiation, heating of a hot plate was also suspended. Then, where a liquid crystal cell is installed on a hot plate, it cooled until cel temperature became 27 degrees C. The obtained liquid crystal device was presenting nebula by light scattering. The light transmittance of the liquid crystal device in this light-scattering condition was 19%, having used light transmittance in the condition of an empty cel as 100%.

[0046] The temperature of the obtained liquid crystal device of this example was kept at 27 degrees C, and 100msec impression of the square wave electrical potential difference of \*\*80V and 1kHz was carried out inter-electrode [ of a liquid crystal device ]. During electrical-potential-difference impression, the transparence condition (light transmittance = 95%) was shown, and, as for the liquid crystal device, after this electrical-potential-difference impression was maintaining the transparence condition (light transmittance = 89%). That is, relaxation of a transparence condition was about 6% in permeability.

[0047] Next, 100msec impression of the square wave electrical potential difference of \*\*80V and 100kHz was carried out at the liquid crystal device of this example. During electrical-potential-difference impression, the light-scattering condition (light transmittance = 10%) was shown, and, as for the liquid crystal device, after electrical-potential-difference impression was maintaining the light-scattering condition (light transmittance = 20%). That is, relaxation of a light-scattering condition was about 10% in permeability.

[0048] Furthermore, the transparence condition (light transmittance after applied-voltage discharge = 89%) and the light-scattering condition (light transmittance after applied-voltage discharge = 20%) of having memory nature were able to be formed in the liquid crystal device of this example by turns by impressing a square wave (the above-mentioned \*\*80V and 1kHz) and a square wave (\*\*80V and 100kHz) to a liquid crystal device alternately with 100msec(s). This situation is shown in drawing 2.

[0049] (Example 1 of a comparison) The giant-molecule precursor 30 weight section which consists [ butyl / acrylic-acid 4-hydroxy ] 40 weight sections and 1,6-hexanediol diacrylate of the 1 weight section in 50 weight sections and "Kayarad R167" by Nippon Kayaku Co., Ltd., the dual tone multifrequency actuation liquid crystal ("DF01XX" by Chisso Corp.) 70 weight section, and the photopolymerization initiator (the "IRUGA cure 184" by Ciba-Geigy) 1 weight section were mixed, and the mixed solution 2 was prepared.

[0050] The liquid crystal device was produced like the example 1 except using the above-mentioned mixed solution 2 instead of a mixed solution 1. The liquid crystal device just behind cool down ready presented nebula by light scattering, made 100% light transmittance in the condition of an empty cel, and the light transmittance of the liquid crystal device in this light-scattering condition was 19%.

[0051] The temperature of the obtained liquid crystal device of this example was kept at 27 degrees C, and 100msec impression of the square wave electrical potential difference of \*\*80V and 1kHz was carried out inter-electrode [ of a liquid crystal device ]. During electrical-potential-difference impression, the transparence condition (light transmittance = 95%) was shown, and, as for the liquid crystal device, after this electrical-potential-difference impression was maintaining the transparence condition (light transmittance = 85%).

[0052] Next, 100msec impression of the square wave electrical potential difference of \*\*80V and 100kHz was carried out at the liquid crystal device of this example. During electrical-potential-difference impression, the light-scattering condition (light transmittance = 10%) was shown, and, as for the liquid crystal device, after electrical-potential-difference impression was maintaining the light-scattering condition (light transmittance = 19%).

[0053] Furthermore, the transparence condition (light transmittance after applied-voltage discharge = 85%) and the light-scattering condition (light transmittance after applied-voltage discharge = 19%) of having memory nature were able to be formed in the liquid crystal device of this example by turns by impressing a square wave (the above-mentioned \*\*80V and 1kHz) and a square wave (\*\*80V and 100kHz) to a liquid crystal device alternately with 100msec(s). That is, relaxation of the transparence condition in the liquid crystal device of this example and a light-scattering condition was 10% and 9% in permeability change, respectively, and its relaxation of a transparence condition was large compared with relaxation of the transparence condition of an example 1.

[0054] (Example 2) After having prepared the ITO electrode in each of two glass substrates, preparing the polyimide film and performing rubbing processing, the liquid crystal device was produced like the example 1 except having used the cel which carried out opposite arrangement and which was constituted through the 5-micrometer spacer.

[0055] The liquid crystal device just behind cool down ready presented nebula by light scattering, made 100% light transmittance in the condition of an empty cel, and the light transmittance of the liquid crystal device in this light-scattering condition was 20%.

[0056] The temperature of the obtained liquid crystal device of this example was kept at 27 degrees C, and 100msec impression of the square wave electrical potential difference of \*\*80V and 1kHz was carried out inter-electrode [ of a liquid crystal device ]. During electrical-potential-difference impression, the transparence condition (light transmittance = 96%) was shown, and, as for the liquid crystal device, after this electrical-potential-difference impression was maintaining the transparence condition (light transmittance = 90%). That is, relaxation of a transparence condition was about 6% in permeability change.

[0057] Next, 100msec impression of the square wave electrical potential difference of \*\*80V and 100kHz was carried out at the liquid crystal device of this example. During electrical-potential-difference impression, the light-scattering condition (light transmittance = 14%) was shown, and, as for the liquid crystal device, after electrical-potential-difference impression was maintaining the light-scattering condition (light transmittance = 21%). That is, relaxation of a light-scattering condition was about 7% in permeability change.

[0058] Furthermore, the transparence condition (light transmittance after applied-voltage discharge = 90%) and the light-scattering condition (light transmittance after applied-voltage discharge = 21%) of having memory nature were able to be formed in the liquid crystal device of this example by turns by impressing a square wave (the above-mentioned \*\*80V and 1kHz) and a square wave (\*\*80V and 100kHz) to a liquid crystal device alternately with 100msec(s).

[0059] (Example 2 of a comparison) The liquid crystal device was produced like the example 2 except having used the mixed solution 2 used in the example 1 of a comparison instead of the mixed solution 1. The liquid crystal device just behind cool down ready presented nebula by light scattering, made 100% light transmittance in the condition of an empty cel, and the light transmittance of the liquid crystal device in this light-scattering condition was 20%.

[0060] The temperature of the obtained liquid crystal device of this example was kept at 27 degrees C, and 100msec impression of the square wave electrical potential difference of \*\*80V and 1kHz was carried out inter-electrode [ of a liquid crystal device ]. During electrical-potential-difference impression, the transparence condition (light transmittance = 96%) was shown, and, as for the liquid crystal device, after this electrical-potential-difference impression was maintaining the transparence condition (light transmittance = 86%).

[0061] Next, 100msec impression of the square wave electrical potential difference of \*\*80V and 100kHz was carried out at the liquid crystal device of this example. During electrical-potential-difference impression, the light-scattering condition (light transmittance = 14%) was shown, and, as for the liquid crystal device, after electrical-potential-difference impression was maintaining the light-scattering condition (light transmittance = 20%).

[0062] Furthermore, the transparence condition (light transmittance after applied-voltage discharge = 86%) and the light-scattering condition (light transmittance after applied-voltage discharge = 20%) of having memory nature were able to be formed in the liquid crystal device of this example by turns by impressing a

square wave (the above-mentioned \*\*80V and 1kHz) and a square wave (\*\*80V and 100kHz) to a liquid crystal device alternately with 100msec(s). That is, relaxation of the transparence condition in the liquid crystal device of this example and a light-scattering condition was 10% and 6% in permeability change, respectively, and its relaxation of a transparence condition was large compared with relaxation of the transparence condition of an example 2.

[0063] (Example 3) The ITO electrode was prepared in each of two glass substrates, and the liquid crystal device was produced like the example 1 except having used the cel which carried out opposite arrangement and which was constituted through the 5-micrometer spacer, without performing orientation processing.

[0064] The liquid crystal device just behind cool down ready presented nebula by light scattering, made 100% light transmittance in the condition of an empty cel, and the light transmittance of the liquid crystal device in this light-scattering condition was 19%.

[0065] The temperature of the obtained liquid crystal device of this example was kept at 27 degrees C, and 100msec impression of the square wave electrical potential difference of \*\*80V and 1kHz was carried out inter-electrode [ of a liquid crystal device ]. During electrical-potential-difference impression, the transparence condition (light transmittance = 96%) was shown, and, as for the liquid crystal device, after this electrical-potential-difference impression was maintaining the transparence condition (light transmittance = 91%). That is, relaxation of a transparence condition was about 5% in permeability change.

[0066] Next, 100msec impression of the square wave electrical potential difference of \*\*80V and 100kHz was carried out at the liquid crystal device of this example. During electrical-potential-difference impression, the light-scattering condition (light transmittance = 14%) was shown, and, as for the liquid crystal device, after electrical-potential-difference impression was maintaining the light-scattering condition (light transmittance = 20%). That is, relaxation of a light-scattering condition was about 6% in permeability change.

[0067] Furthermore, the transparence condition (light transmittance after applied-voltage discharge = 91%) and the light-scattering condition (light transmittance after applied-voltage discharge = 20%) of having memory nature were able to be formed in the liquid crystal device of this example by turns by impressing a square wave (the above-mentioned \*\*80V and 1kHz) and a square wave (\*\*80V and 100kHz) to a liquid crystal device alternately with 100msec(s).

[0068] (Example 3 of a comparison) The liquid crystal device was produced like the example 3 except having used the mixed solution 2 used in the example 1 of a comparison instead of the mixed solution 1. The liquid crystal device just behind cool down ready presented nebula by light scattering, made 100% light transmittance in the condition of an empty cel, and the light transmittance of the liquid crystal device in this light-scattering condition was 19%.

[0069] The temperature of the obtained liquid crystal device of this example was kept at 27 degrees C, and 100msec impression of the square wave electrical potential difference of \*\*80V and 1kHz was carried out inter-electrode [ of a liquid crystal device ]. During electrical-potential-difference impression, the transparence condition (light transmittance = 96%) was shown, and, as for the liquid crystal device, after this electrical-potential-difference impression was maintaining the transparence condition (light transmittance = 85%).

[0070] Next, 100msec impression of the square wave electrical potential difference of \*\*80V and 100kHz was carried out at the liquid crystal device of this example. During electrical-potential-difference impression, the light-scattering condition (light transmittance = 14%) was shown, and, as for the liquid crystal device, after electrical-potential-difference impression was maintaining the light-scattering condition (light transmittance = 19%).

[0071] Furthermore, the transparence condition (light transmittance after applied-voltage discharge = 85%) and the light-scattering condition (light transmittance after applied-voltage discharge = 19%) of having memory nature were able to be formed in the liquid crystal device of this example by turns by impressing a square wave (the above-mentioned \*\*80V and 1kHz) and a square wave (\*\*80V and 100kHz) to a liquid crystal device alternately with 100msec(s). That is, relaxation of the transparence condition in the liquid crystal device of this example and a light-scattering condition was 11% and 5% in permeability change, respectively, and its relaxation of a transparence condition was large compared with relaxation of the transparence condition of an example 2.

[0072] (Example 4) The black optical absorption layer was prepared in one front face (rear face) of the liquid crystal device of an example 1.

[0073] When the square wave electrical potential difference of \*\*80V and 1kHz was impressed to this liquid crystal device and having been observed from the front face, the black which is a color of an optical



absorption layer was observed. Moreover, black was presented even after canceling electrical-potential-difference impression.

[0074] Next, when the square wave electrical potential difference of \*\*80V and 100kHz was impressed to the liquid crystal device of this example, the liquid crystal device was presenting the light-scattering condition, i.e., white. Moreover, white was maintained even after canceling electrical-potential-difference impression.

[0075] Furthermore, the black and white which have memory nature were able to be formed by turns by impressing a square wave (the above-mentioned \*\*80V and 1kHz) and a square wave (\*\*80V and 100kHz) to a liquid crystal device alternately with 100msec(s).

[0076] (Example 5) The giant-molecule precursor 50 weight section which consists 50 weight sections and 1,6-hexanediol diacrylate of the 5 weight sections in acrylic-acid 4-hydroxy butyl, the dual tone multifrequency actuation liquid crystal ("DF01XX" by Chisso Corp.) 50 weight section, the silane coupling agent (octadecyl triethoxysilane) 3 weight section, and the photopolymerization initiator (the "IRUGA cure 184" by Ciba-Geigy) 1 weight section were mixed, and the mixed solution 3 was prepared.

[0077] The liquid crystal device was produced like the example 1 except using the above-mentioned mixed solution 3 instead of a mixed solution 1. The liquid crystal device just behind cool down ready presented nebula by light scattering, made 100% light transmittance in the condition of an empty cel, and the light transmittance of the liquid crystal device in this light-scattering condition was 19%.

[0078] The temperature of the obtained liquid crystal device of this example was kept at 27 degrees C, and 100msec impression of the square wave electrical potential difference of \*\*80V and 1kHz was carried out inter-electrode [ of a liquid crystal device ]. During electrical-potential-difference impression, the transparence condition (light transmittance = 95%) was shown, and, as for the liquid crystal device, after this electrical-potential-difference impression was maintaining the transparence condition (light transmittance = 88%). That is, relaxation of a transparence condition was about 7% in permeability change.

[0079] Next, 100msec impression of the square wave electrical potential difference of \*\*80V and 100kHz was carried out at the liquid crystal device of this example. During electrical-potential-difference impression, the light-scattering condition (light transmittance = 10%) was shown, and, as for the liquid crystal device, after electrical-potential-difference impression was maintaining the light-scattering condition (light transmittance = 22%).

[0080] Furthermore, the transparence condition (light transmittance after applied-voltage discharge = 88%) and the light-scattering condition (light transmittance after applied-voltage discharge = 22%) of having memory nature were able to be formed in the liquid crystal device of this example by turns by impressing a square wave (the above-mentioned \*\*80V and 1kHz) and a square wave (\*\*80V and 100kHz) to a liquid crystal device alternately with 100msec(s).

[0081] (Example 4 of a comparison) The giant-molecule precursor 50 weight section which consists 50 weight sections and 1,6-hexanediol diacrylate of the 5 weight sections in acrylic-acid 4-hydroxy butyl, the dual tone multifrequency actuation liquid crystal ("DF01XX" by Chisso Corp.) 50 weight section, and the photopolymerization initiator (the "IRUGA cure 184" by Ciba-Geigy) 1 weight section were mixed, and the mixed solution 4 was prepared.

[0082] The liquid crystal device was produced like the example 5 except using the above-mentioned mixed solution 4 instead of a mixed solution 3. The liquid crystal device just behind cool down ready presented nebula by light scattering, made 100% light transmittance in the condition of an empty cel, and the light transmittance of the liquid crystal device in this light-scattering condition was 19%.

[0083] The temperature of the obtained liquid crystal device of this example was kept at 27 degrees C, and 100msec impression of the square wave electrical potential difference of \*\*80V and 1kHz was carried out inter-electrode [ of a liquid crystal device ]. During electrical-potential-difference impression, the transparence condition (light transmittance = 95%) was shown, and, as for the liquid crystal device, after this electrical-potential-difference impression was maintaining the transparence condition (light transmittance = 80%).

[0084] Next, 100msec impression of the square wave electrical potential difference of \*\*80V and 100kHz was carried out at the liquid crystal device of this example. During electrical-potential-difference impression, the light-scattering condition (light transmittance = 10%) was shown, and, as for the liquid crystal device, after electrical-potential-difference impression was maintaining the light-scattering condition (light transmittance = 21%).

[0085] Furthermore, the transparence condition (light transmittance after applied-voltage discharge = 80%) and the light-scattering condition (light transmittance after applied-voltage discharge = 21%) of having

memory nature were able to be formed in the liquid crystal device of this example by turns by impressing a square wave (the above-mentioned \*\*80V and 1kHz) and a square wave (\*\*80V and 100kHz) to a liquid crystal device alternately with 100msec(s). That is, relaxation of the transparence condition in the liquid crystal device of this example and a light-scattering condition was 15% and 11% in permeability change, respectively, and its relaxation of a transparence condition was large compared with relaxation of the transparence condition of an example 5.

[0086]

[Effect of the Invention] As explained above, according to this invention, there is no display nonuniformity and it has memory nature by high-speed responsibility, and the liquid crystal device by which relaxation of a transparence condition was controlled especially can be offered, without passing through a complicated production process, and it can apply preferably as a display device or an optical shutter component.

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[Translation done.]



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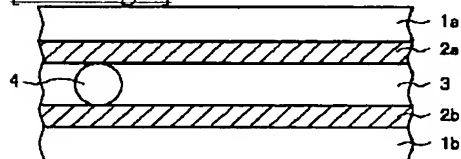
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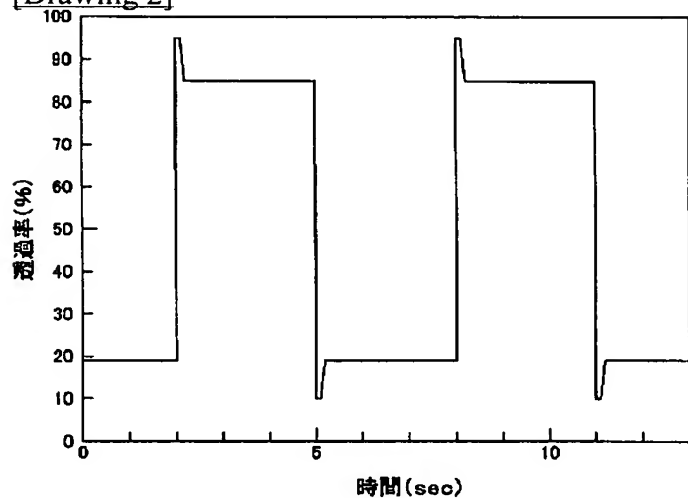
DRAWINGS

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[Drawing 1]



[Drawing 2]



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[Translation done.]

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